



# **Characterization and Monitoring at the Hanford 100H Site using Geophysical Data**

**S. Hubbard, K. Williams, J. Peterson, J. Chen**





# Geophysical Characterization & Monitoring, Hanford 100H

## ◆ *Field Scale\_Characterization and Monitoring*

### ❖ Use to develop field plan:

- Location of Injection Experiment
- Location of Lactate injection interval(s)
- Injection rate and sampling scenarios
- K zonation within Hanford Sands

### ❖ Use to monitor system transformations during stimulation

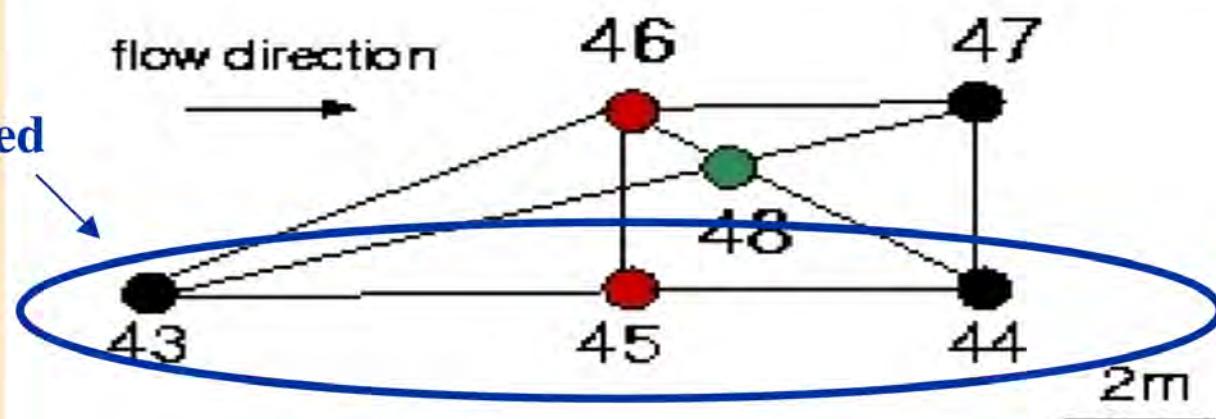
- Image HRC distribution a a function of Heterogeneity
- Interpretation of System Transformations in response to stimulation
- Water table fluctuations

We will discuss items in RED font.....





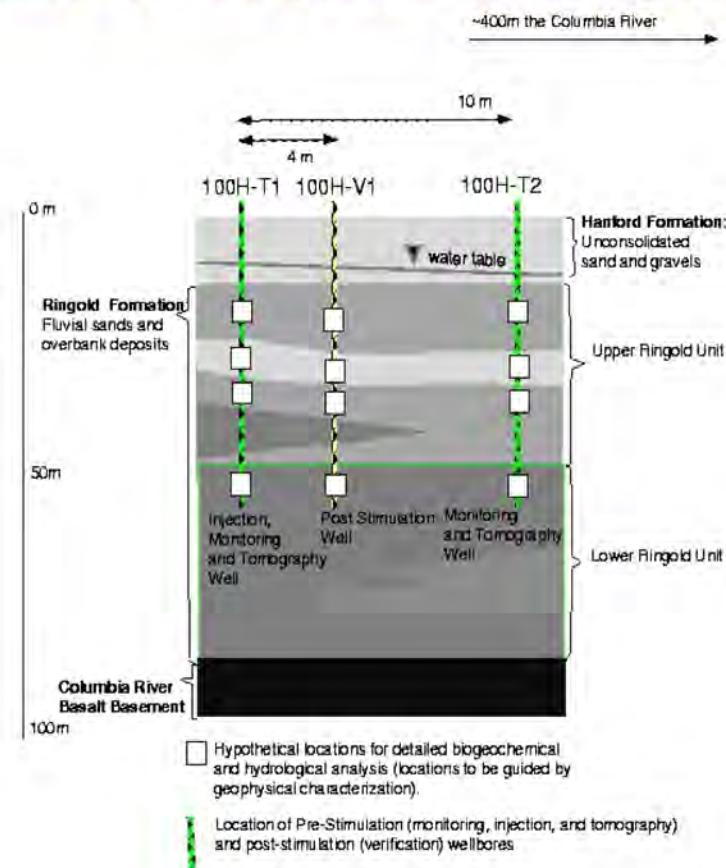
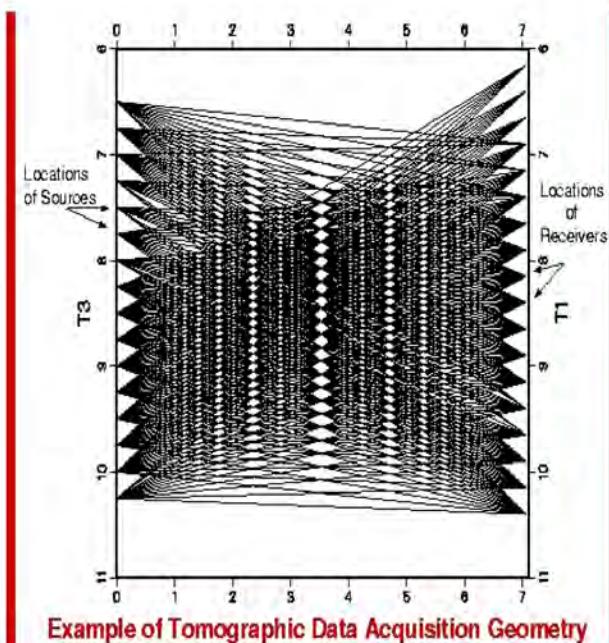
Steel cased



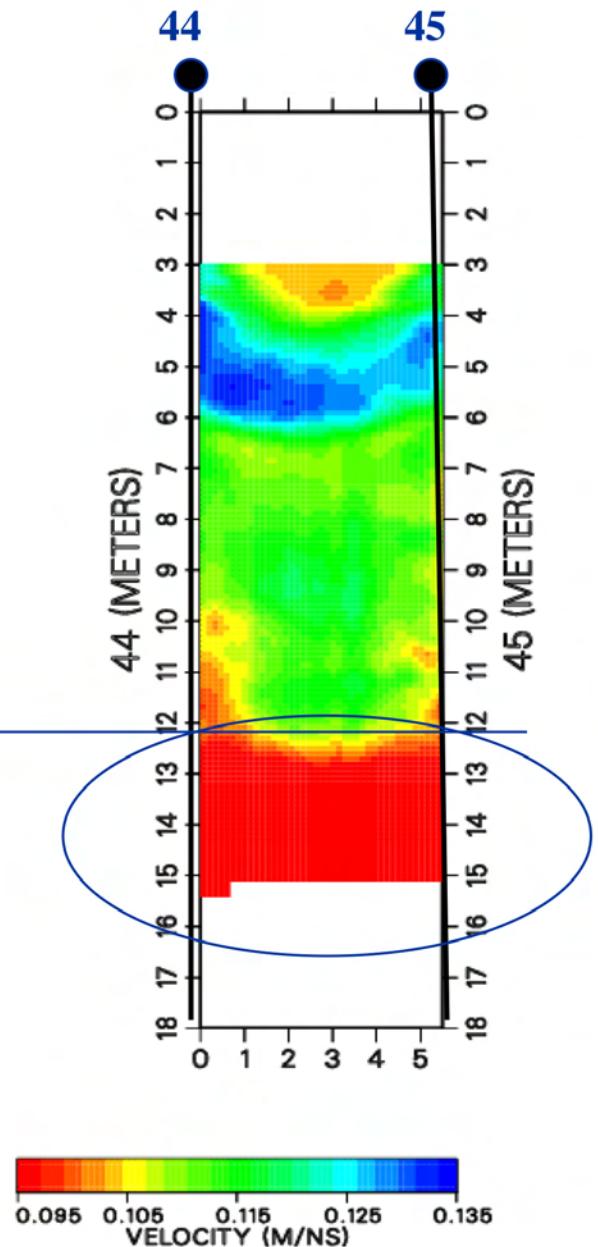
- Monitoring Wells (47 is proposed)
- Injection Wells (46 is proposed)
- Proposed verification well 48
- ✓ Proposed tomographic data acquisition traverses



- Radar Tomography: 45-44 (vadose and saturated zones)
  - 100 MHz
  - 1/8m spacing
- Seismic Tomography: 43-44 and 45-44 (saturated zone)



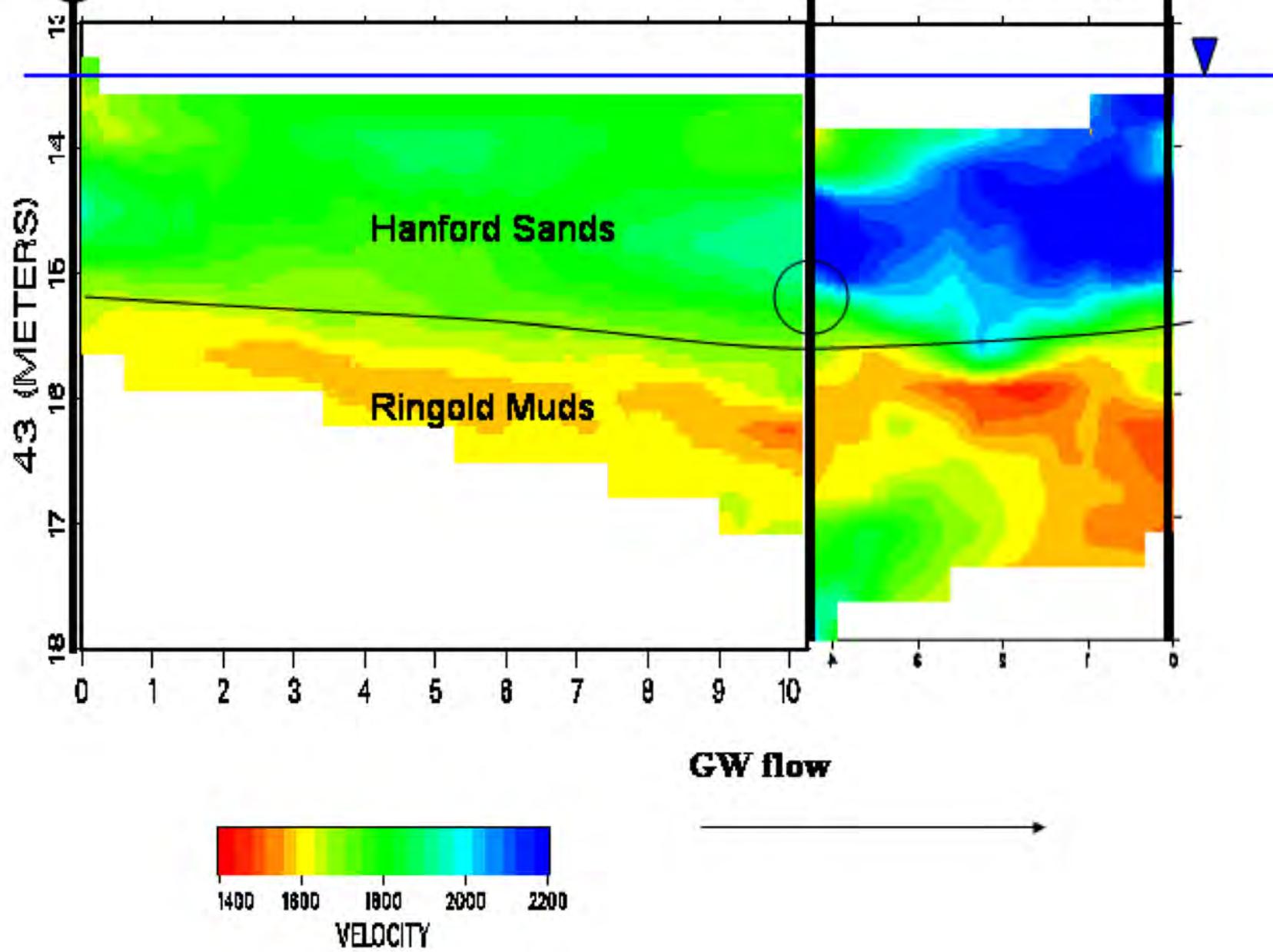
**Radar Tomography:**  
**Vadose Zone**  
**versus the**  
**Saturated zone**



**Subsequent Images  
all in saturated zone**

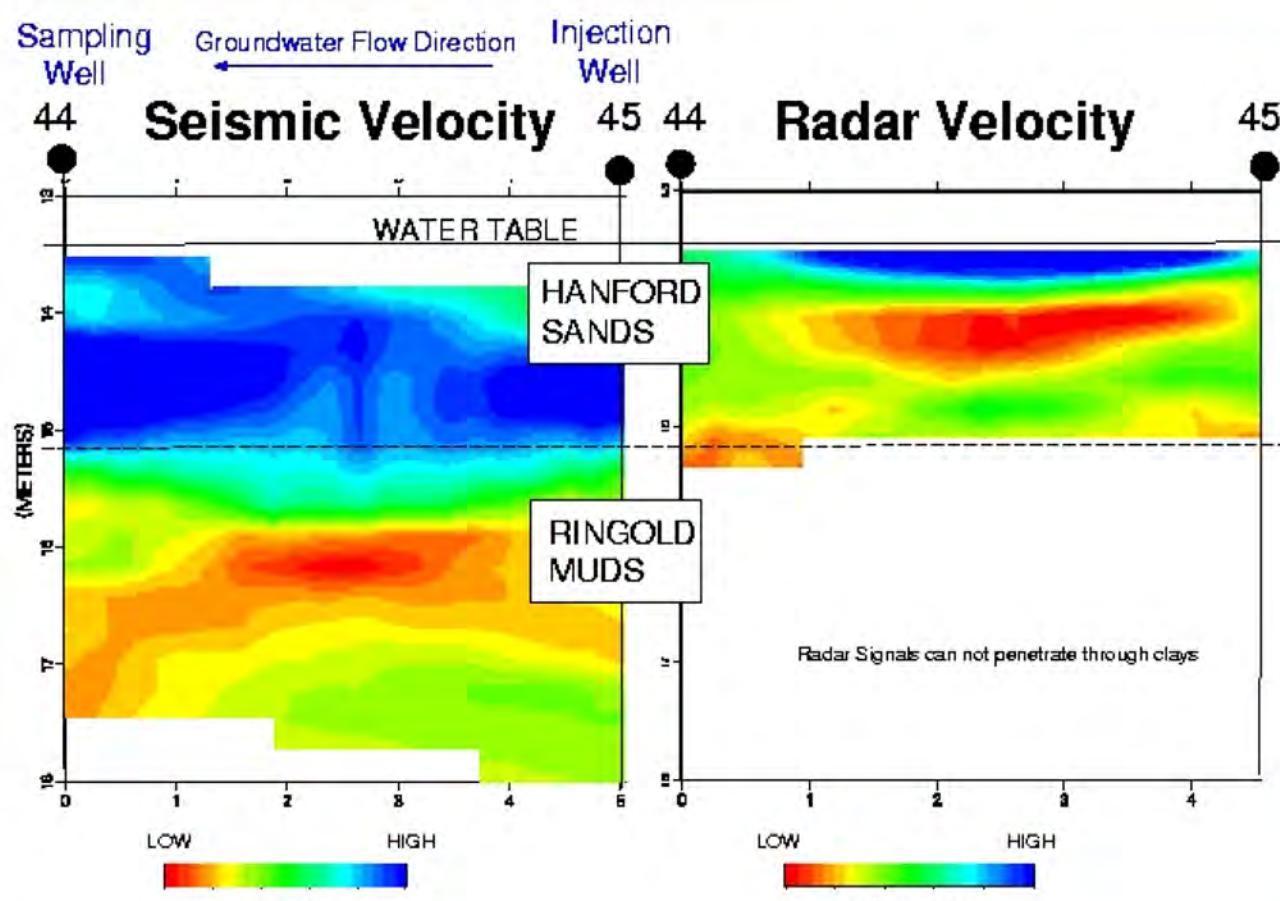
## Hanford Seismic Tomography Velocities

43                    45 (I)                    44 (M)





- Hanford Sands and Ringold Muds Distinguished;
- Radar signals attenuated within muds;
- Some small variability within Hanford Sands.

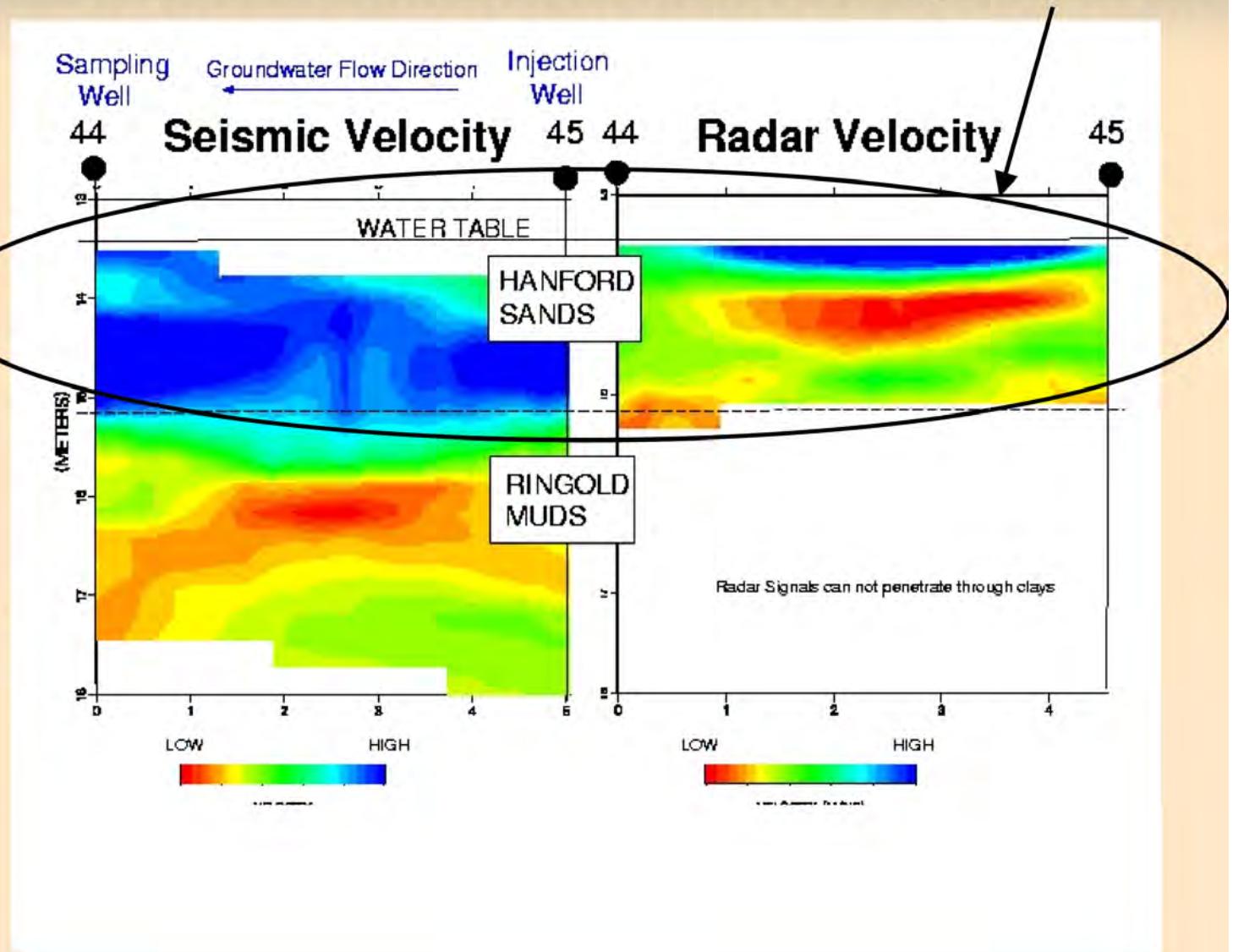


Comparison of Radar and Seismic Images between 44-45



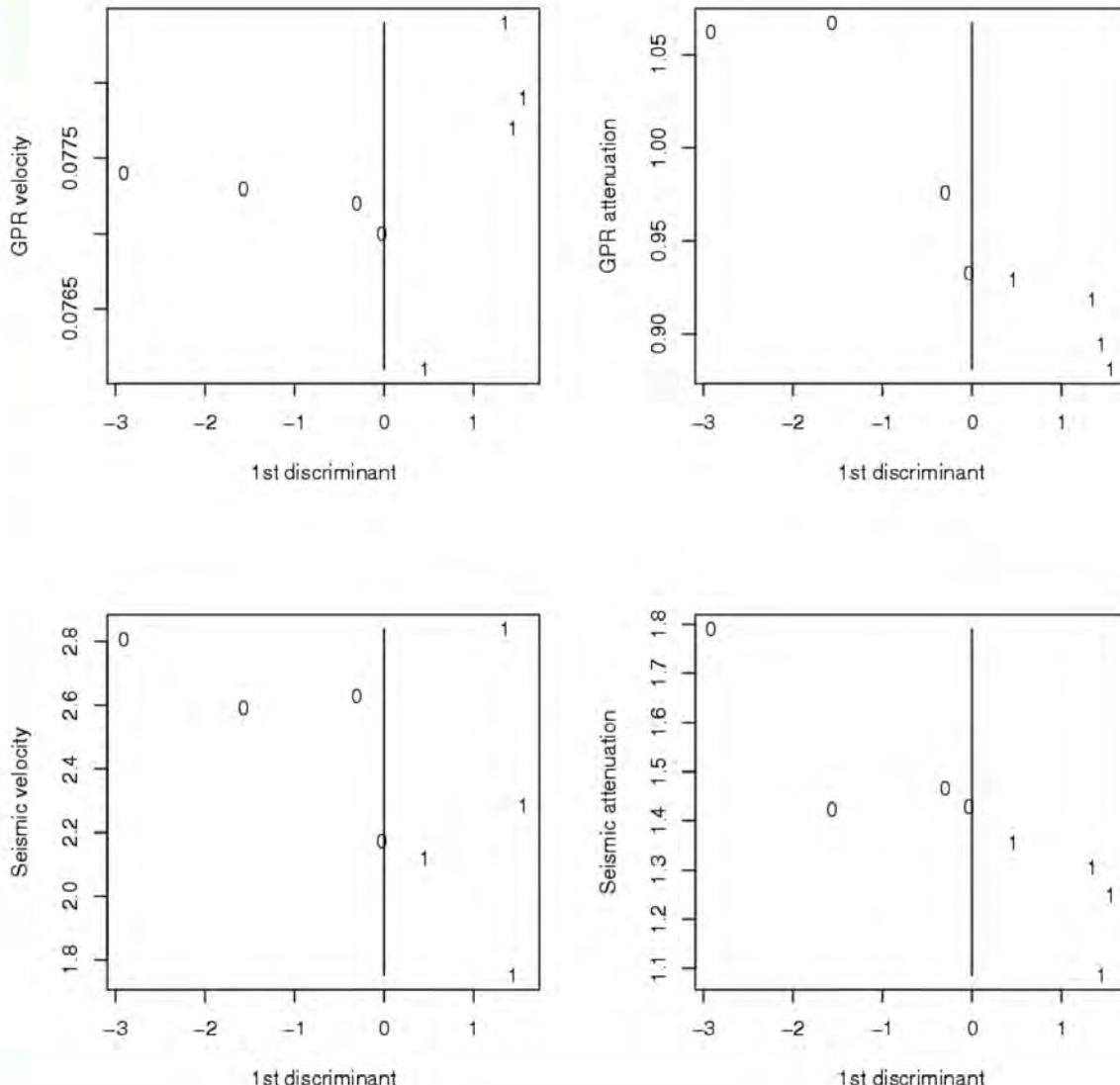
# Estimate K within Hanford Sand Injection Zone

- Radar signals attenuated within muds;
- Hanford Sands and Ringold Distinguished;
- Small variability within Hanford Sands.



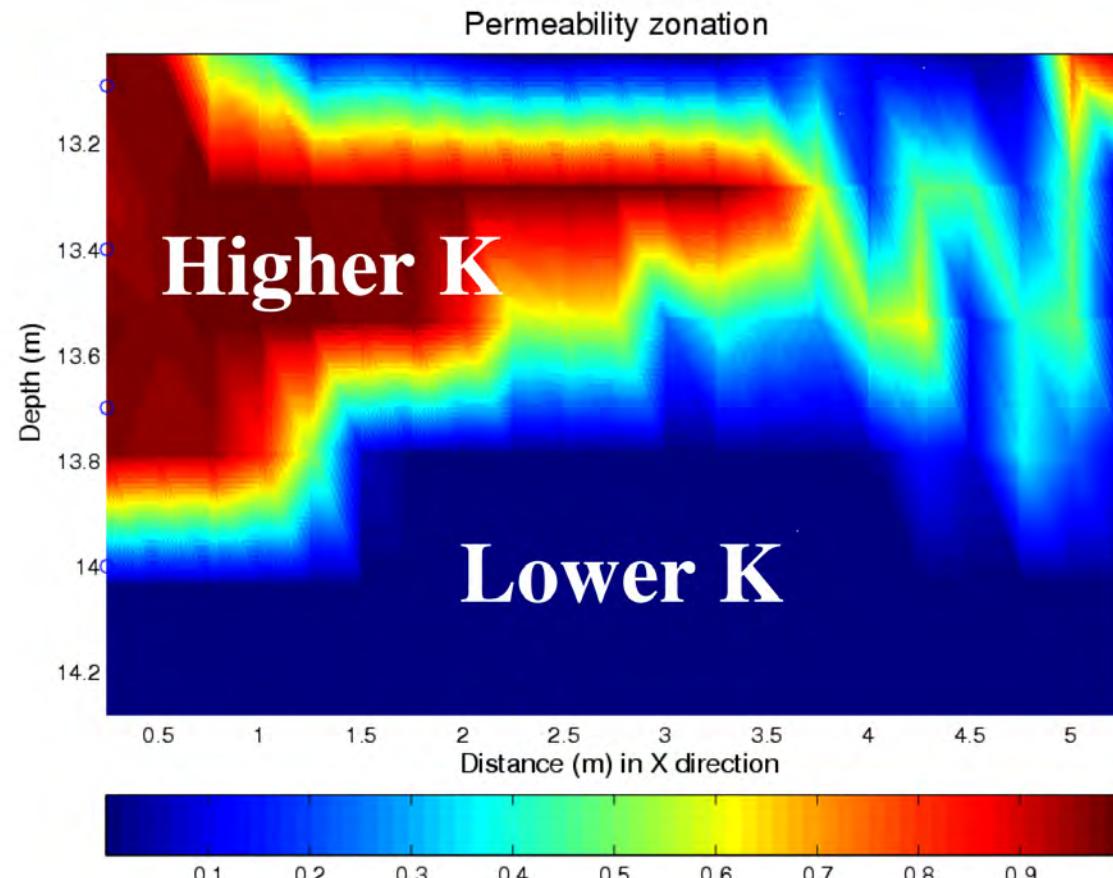
# 1. K Zonation within Hanford Sands using Discriminate Analysis Techniques

1. Discriminate analysis of radar velocity, radar attenuation, seismic velocity, seismic attenuation, and sparse flowmeter data;
2. Indicator Cutoff – K median value
3. Good Zonation





## K zonation within Hanford Sands



Based on Median lnK value from flowmeter data of -3 cm/s



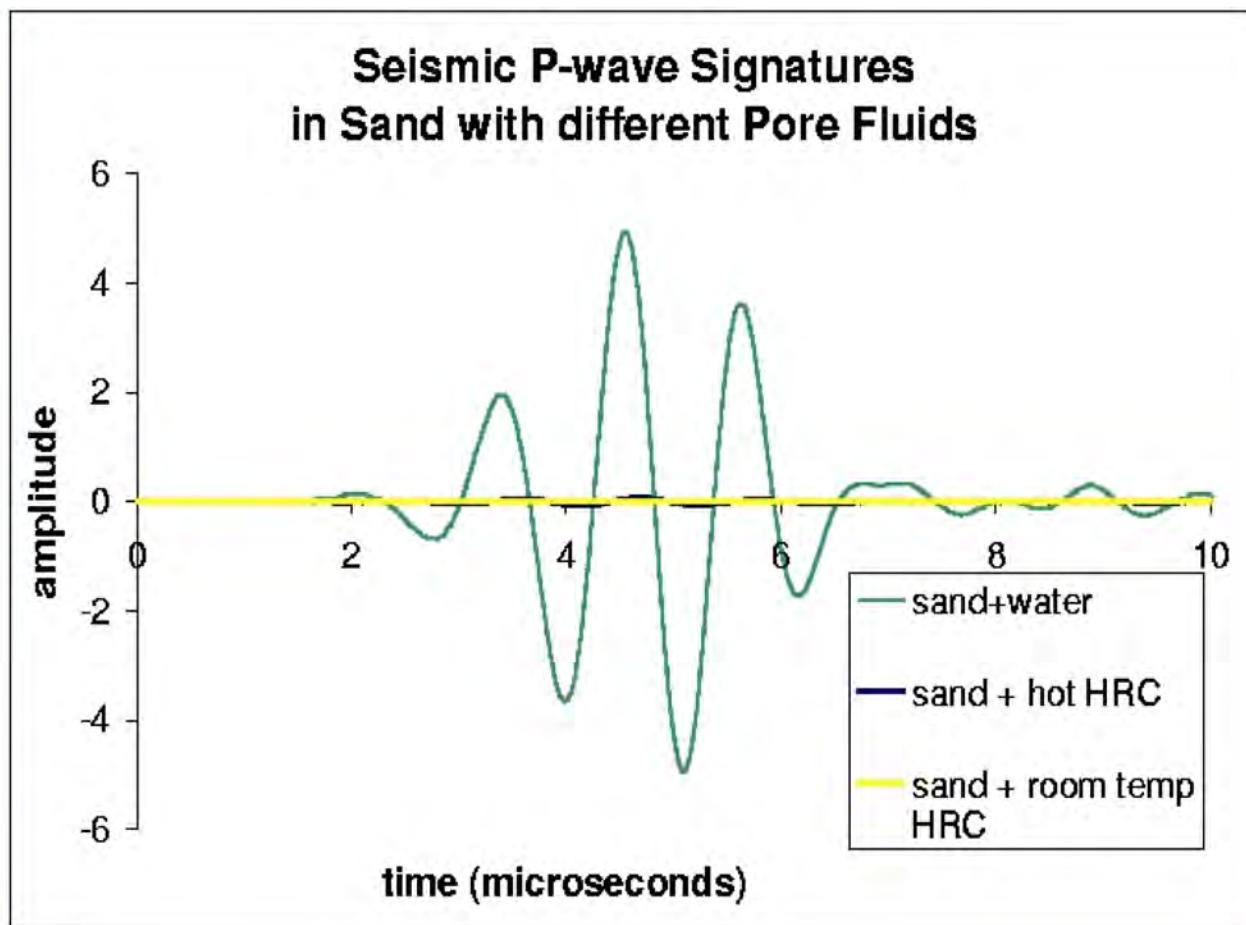
## 2. Geophysical Responses to HRC

- ◆ Seismic Attenuation
- ◆ Radar Velocity
- ◆ Electrical Conductivity
  - ❖ At the laboratory scale (review)
  - ❖ At the field scale (new)





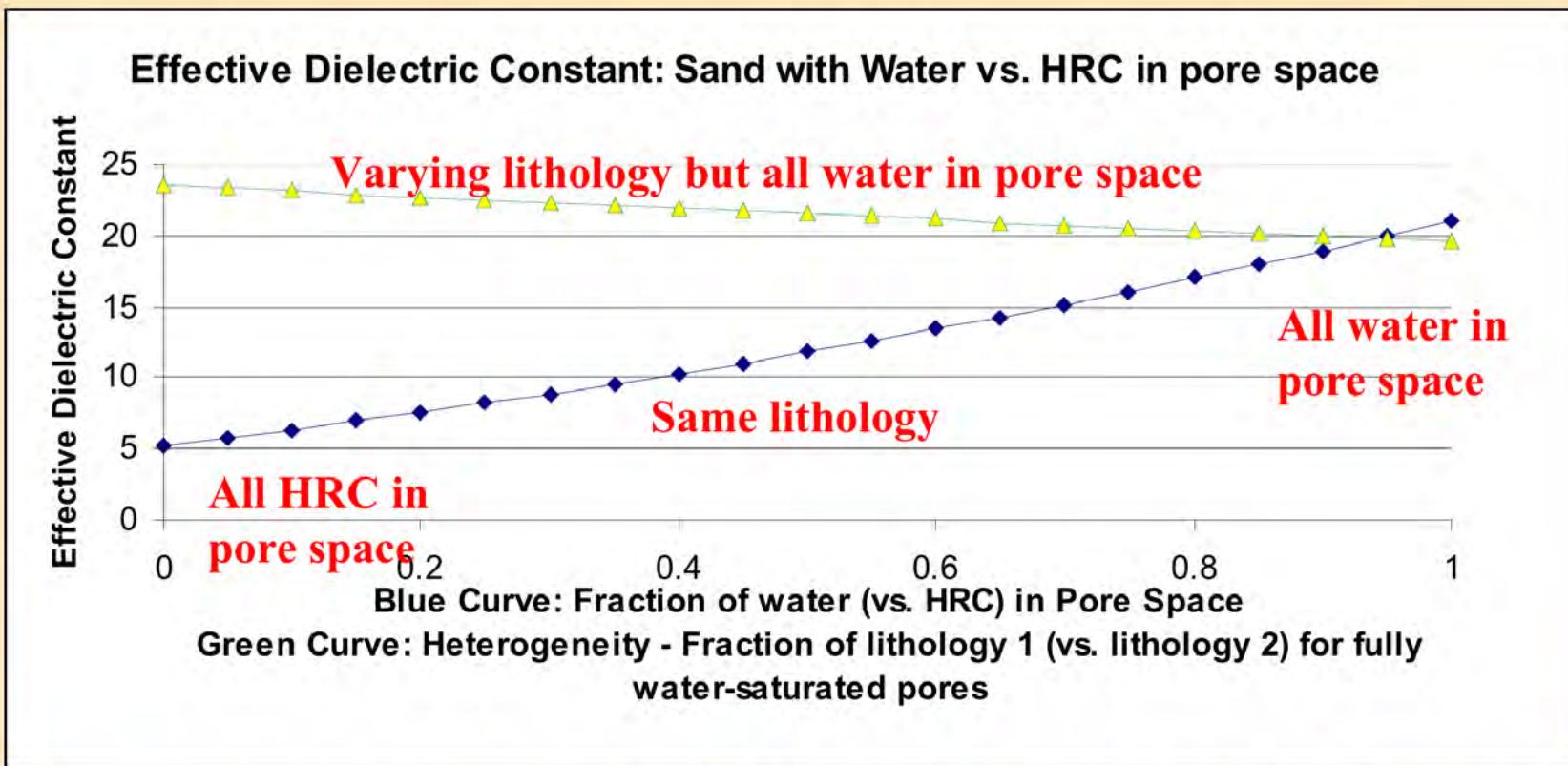
## Seismic Signature of HRC versus water within Hanford-like soils



**Significant reduction in seismic amplitude when HRC replaces pore water in the pore space of a Hanford sand sample →**

(patchy distribution scattering?)

## Modeled Effect of HRC on Radar Dielectric Constant compared to influence of heterogeneity:

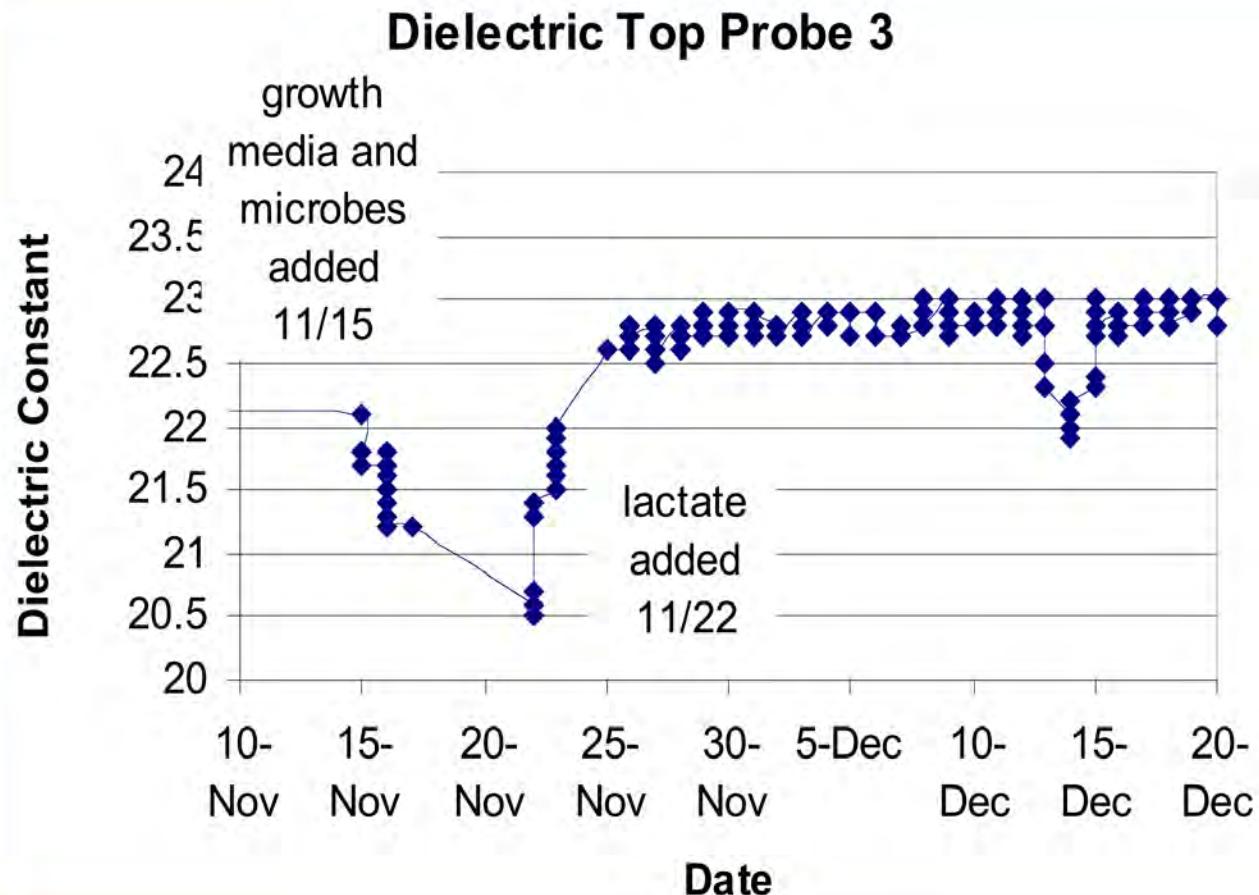


Replacement of pore water by HRC should decrease dielectric constant



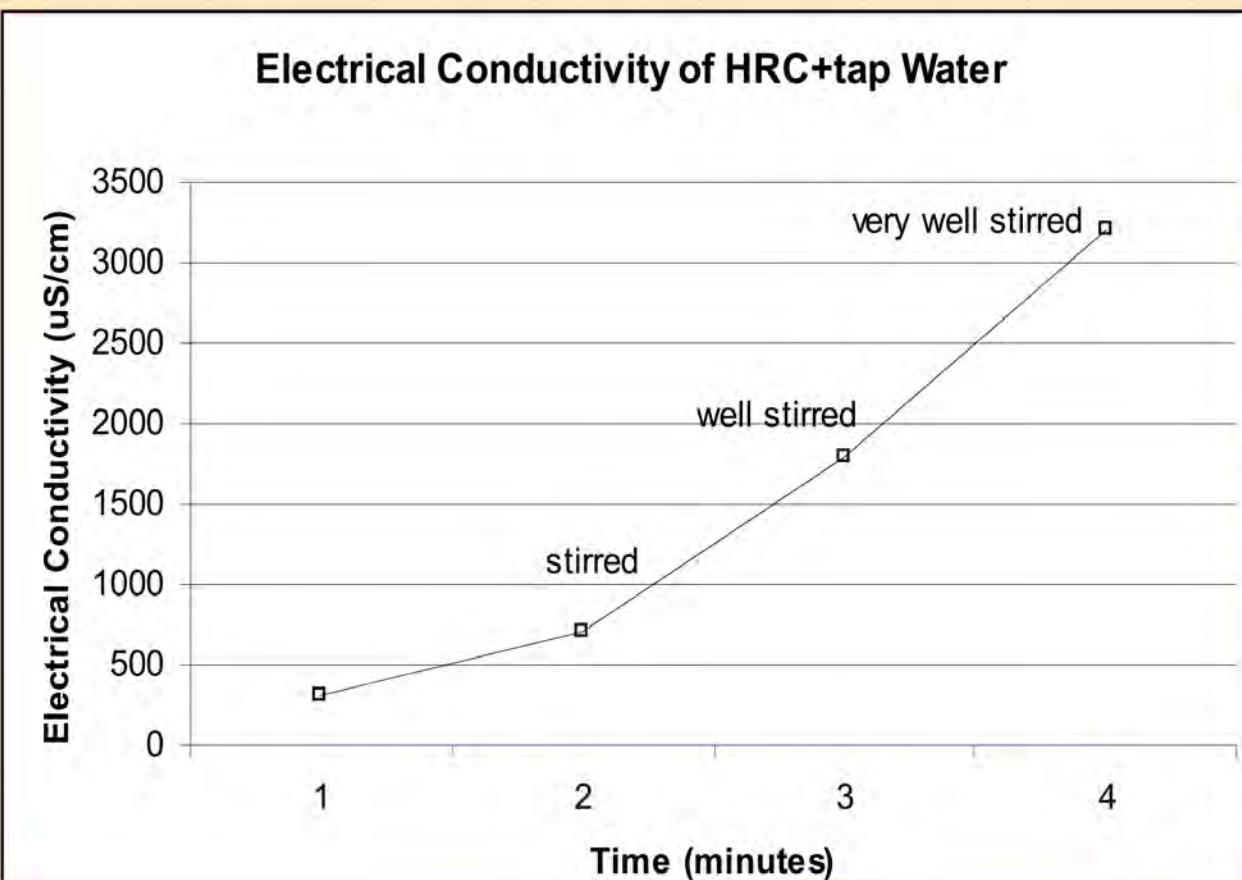
Dielectric Constant of air=1, water=80, HRC=6

## Lab-scale column study: Lactate solution displacing Pore water results in dielectric constant drop





## Electrical Conductivity of HRC over time (with mixing)



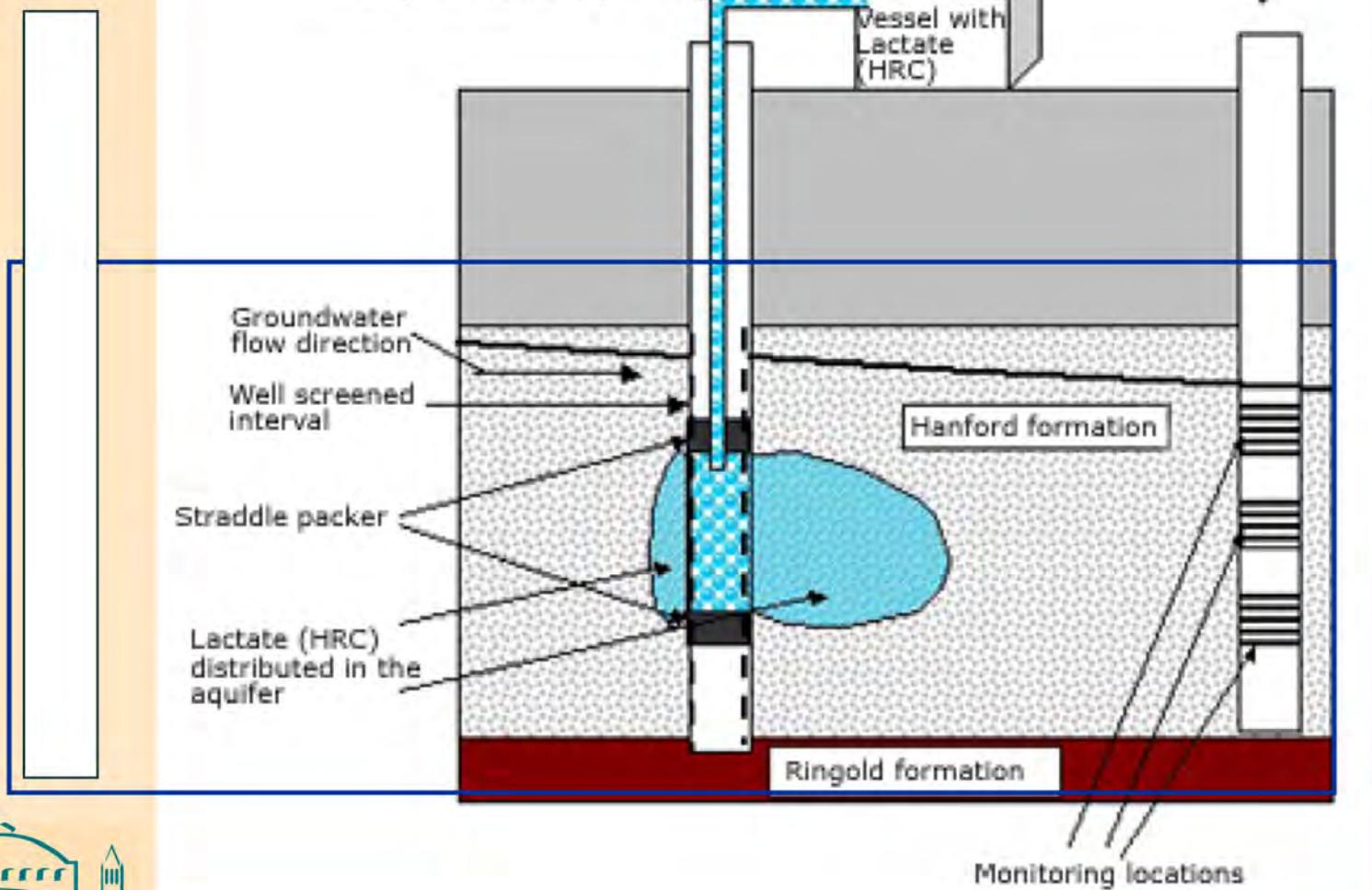


## Field-Scale, Time-Lapse Monitoring of HRC Injection

43

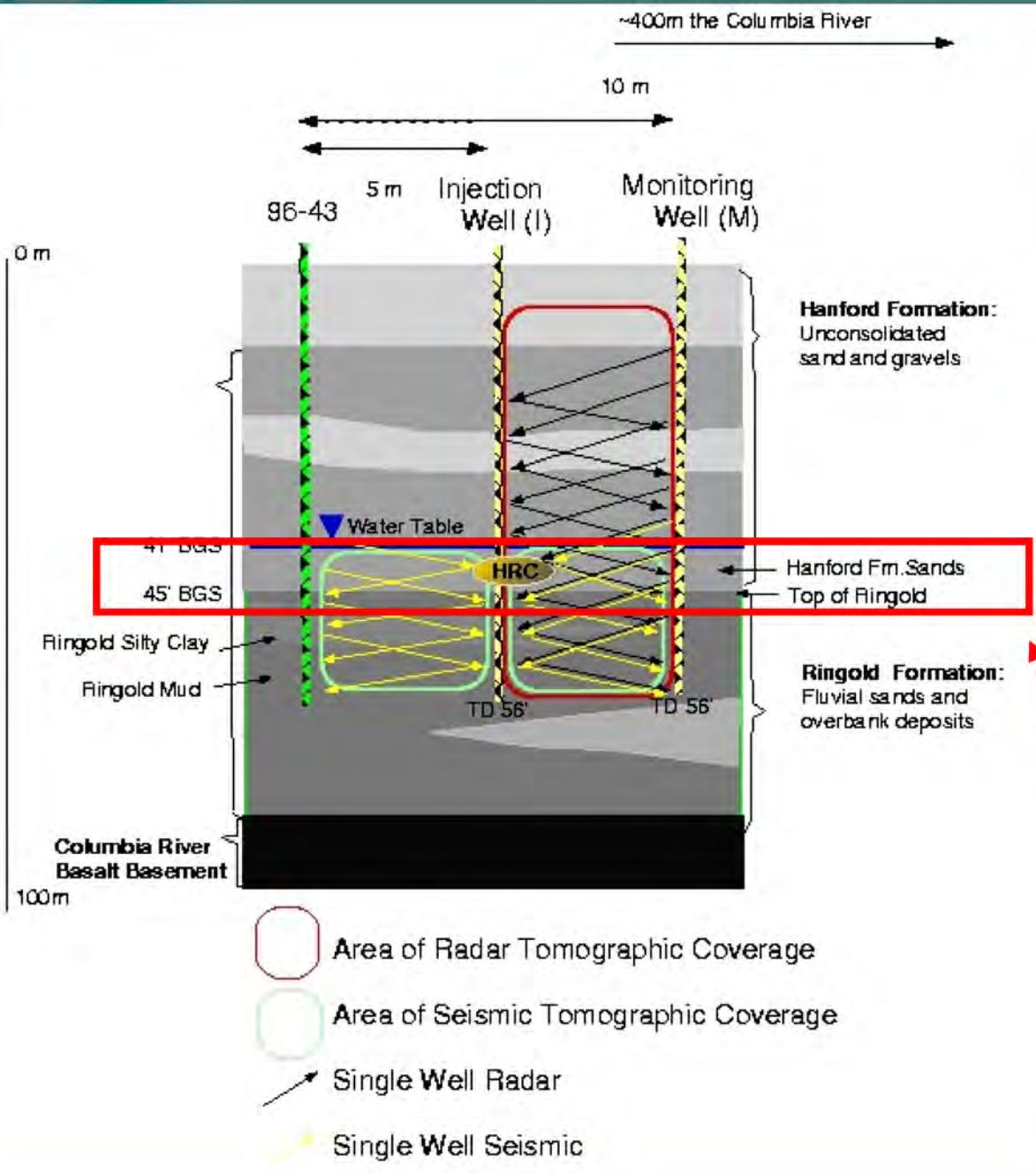
45

Monitoring well 44



# EXPERIMENT TIMELINE





\* Prior data collection  
(baseline)

\* Posterior data  
collection:

- hours
- days
- weeks
- months

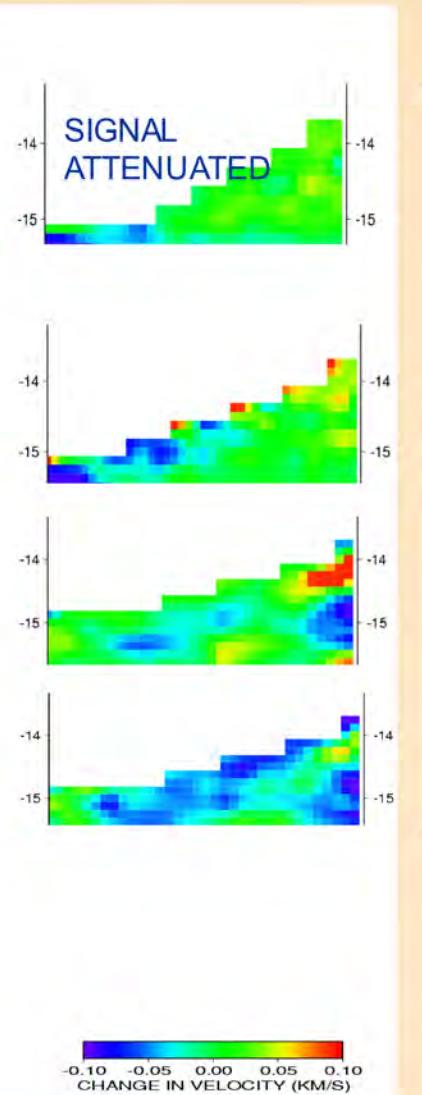
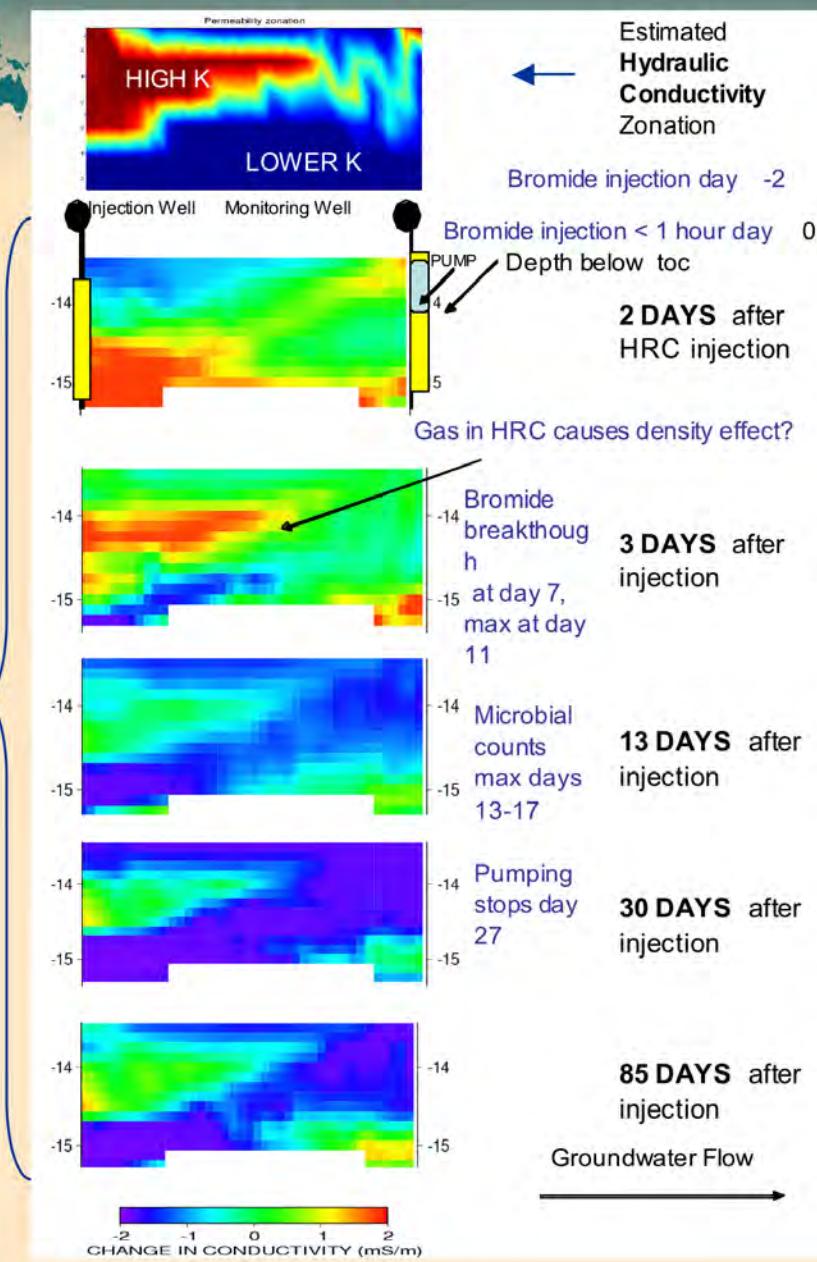
after injection and in  
conjunction with  
wellbore samples.

Data: Seismic  
Radar  
Estimated EC:

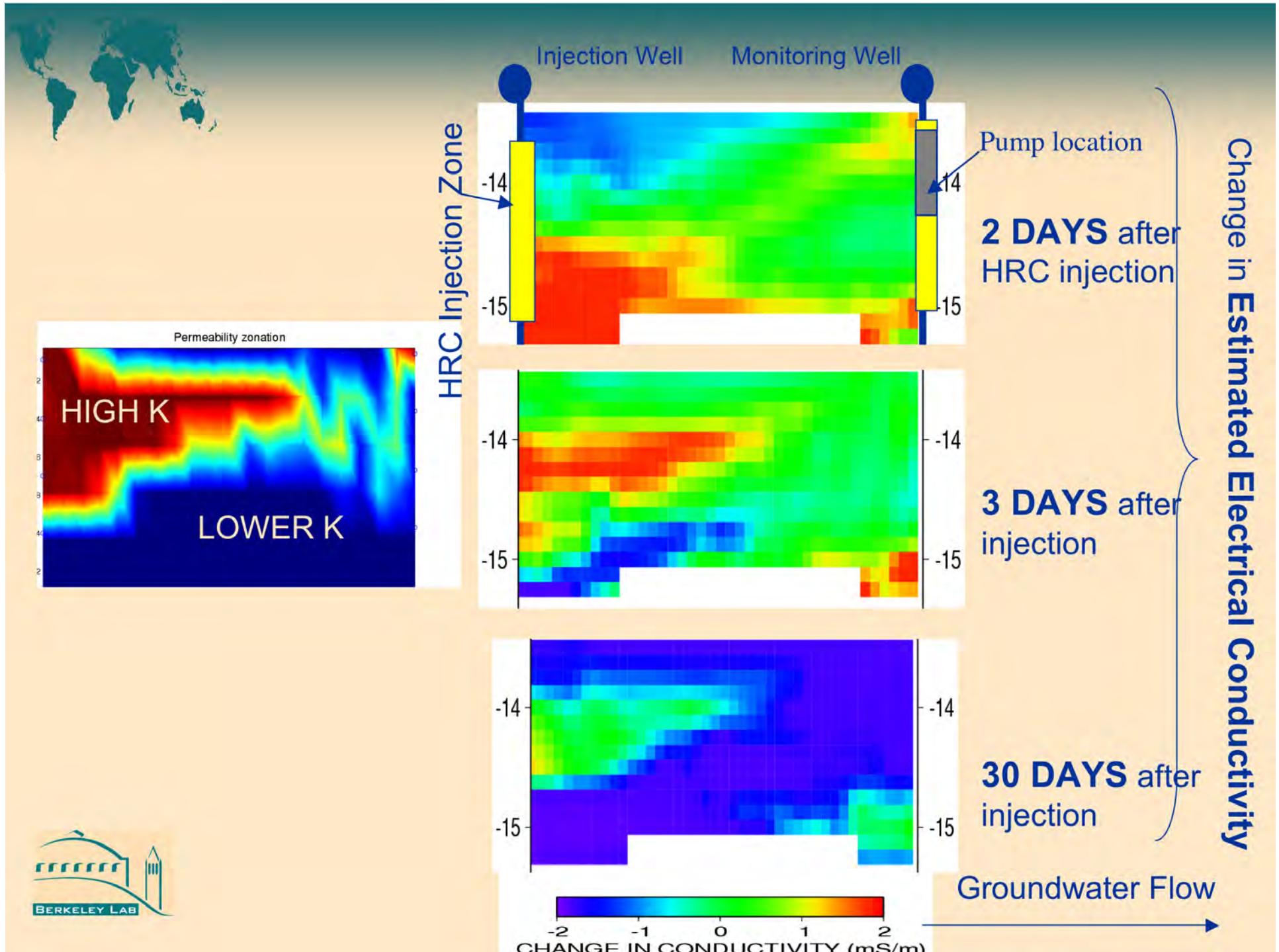
$$\sigma[mS/m] \approx \frac{\alpha[dB/m]\sqrt{\kappa}}{1.64}$$

# Changes in Geophysical Attributes after HRC Injection

## Estimated Changes in Electrical Conductivity

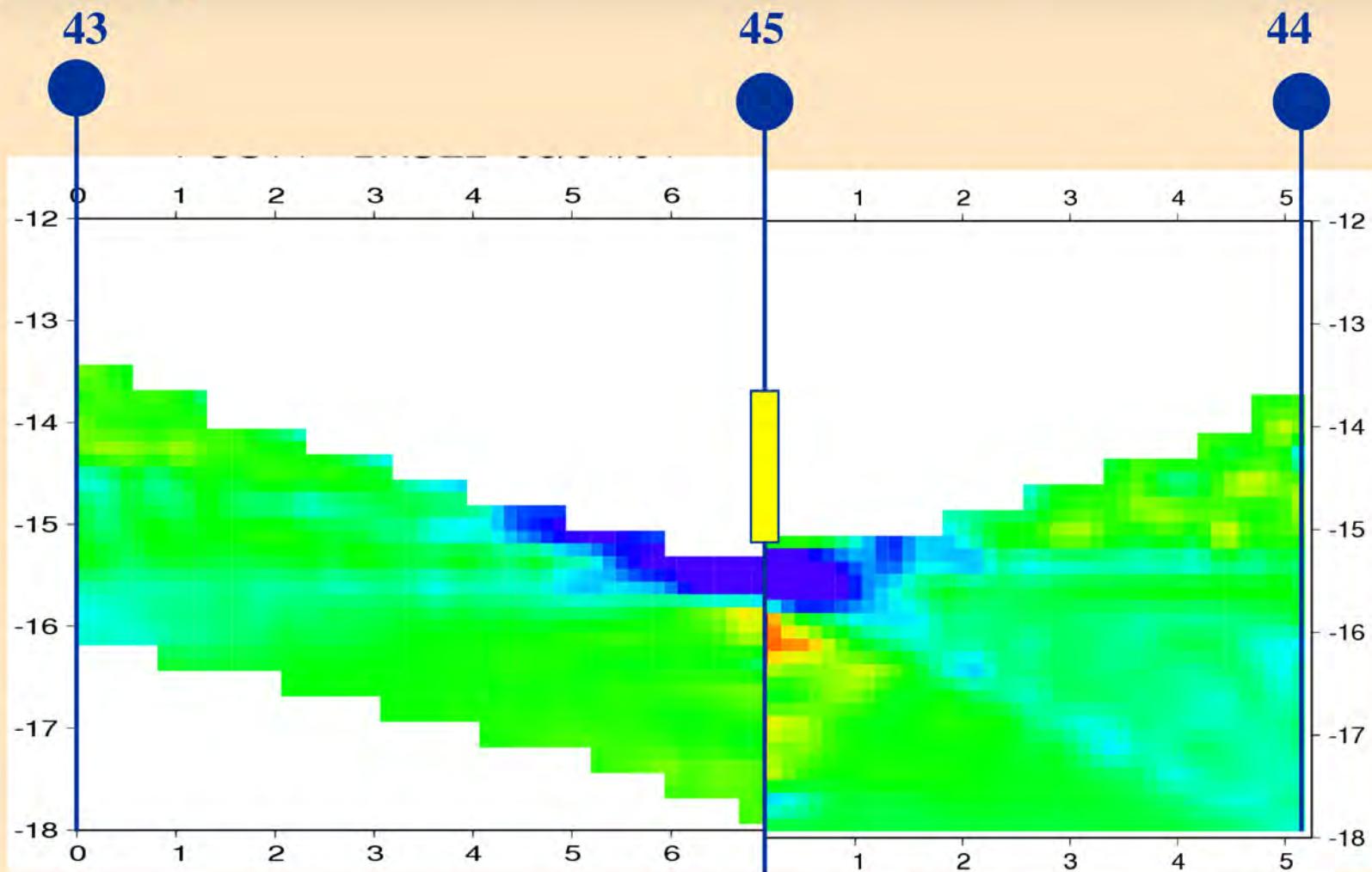


## Estimated Changes in Seismic Velocity



BERKELEY LAB

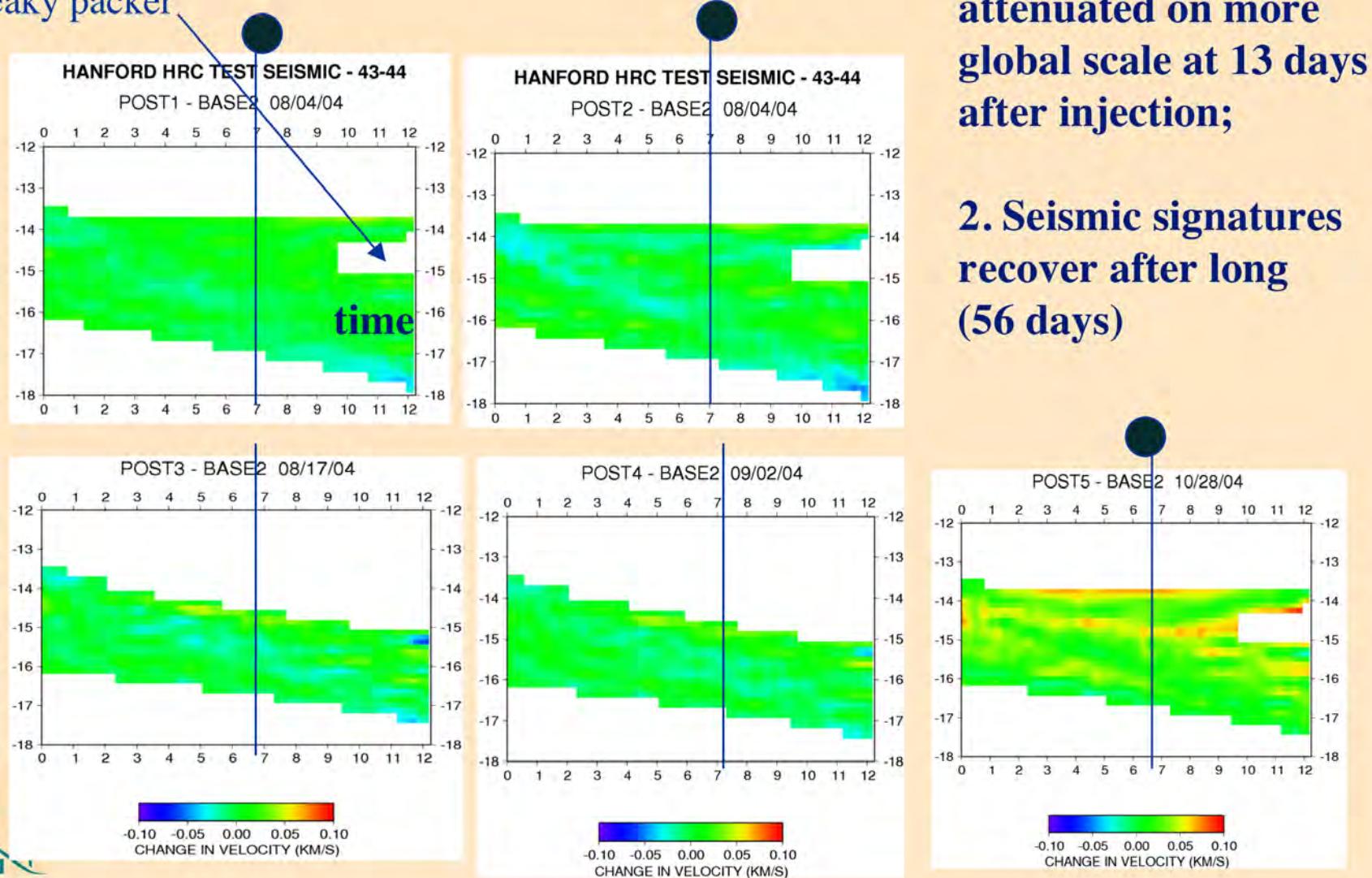
## Seismic Velocity Response: Difference after 2 Days

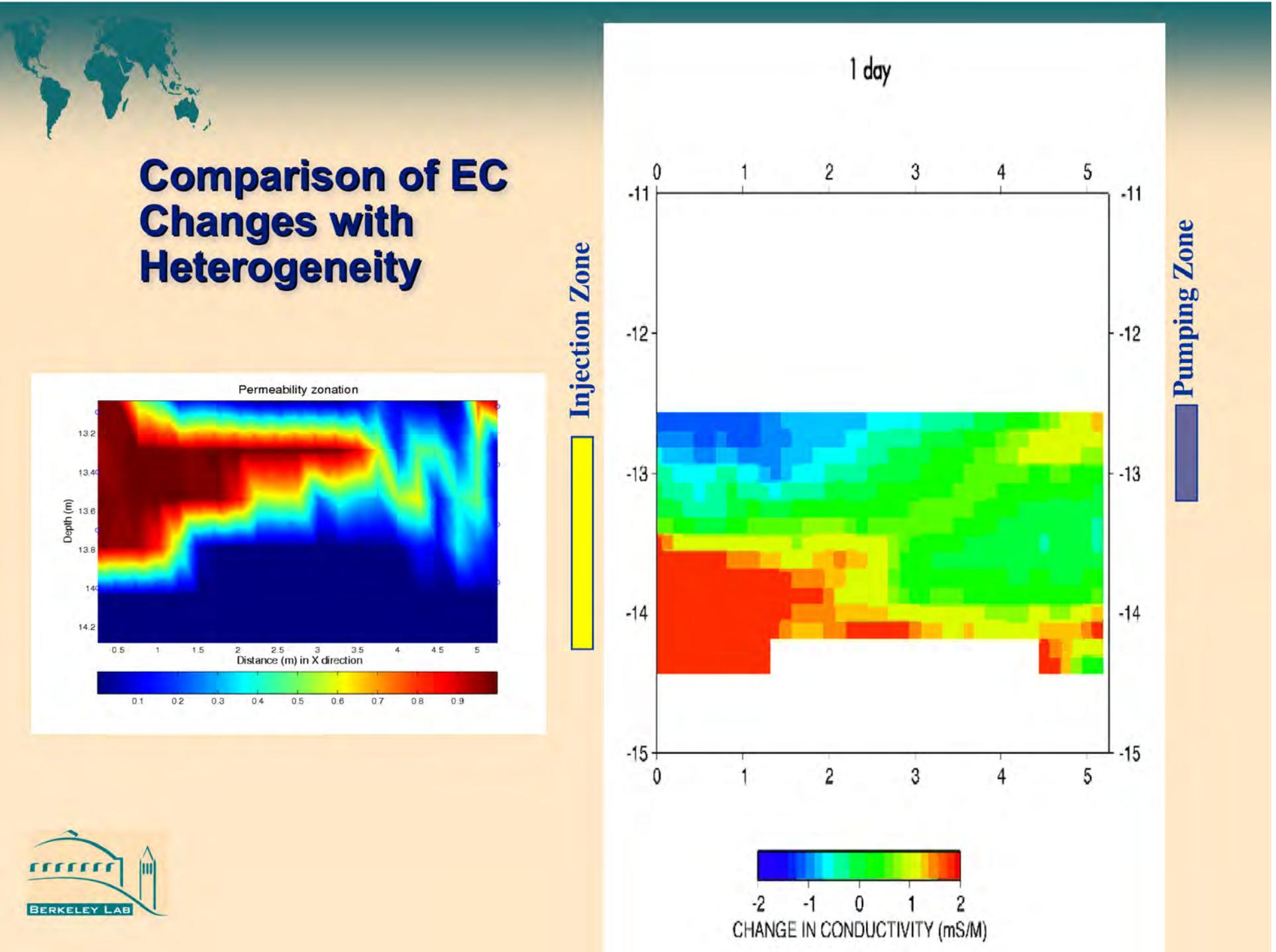


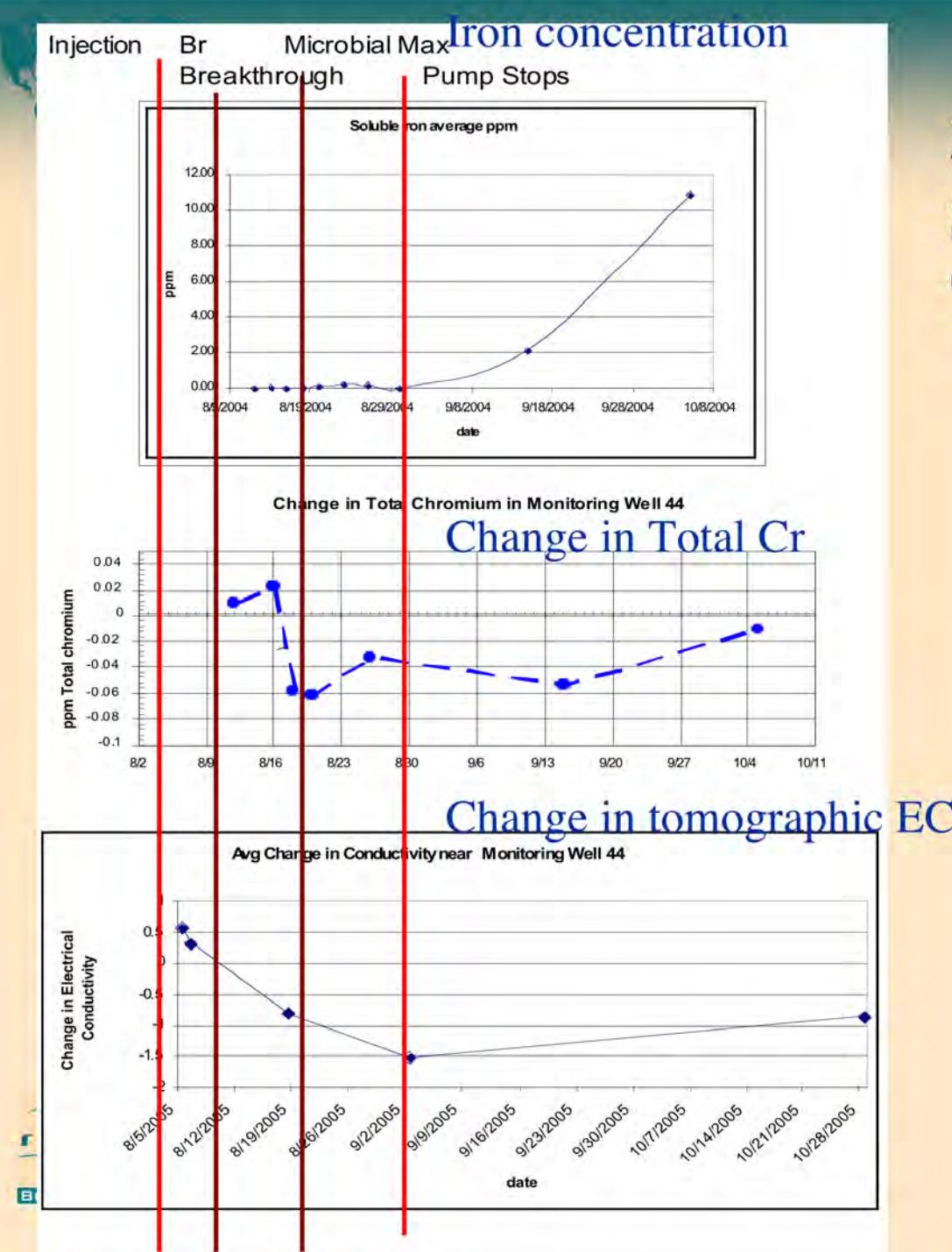
Tomography data collected using well 45 shows that the presence of HRC at the injection well kills the seismic signal in both directions

## Change in Seismic Velocity obtained using outer wellbores only suggest that:

Seismic signature  
of leaky packer



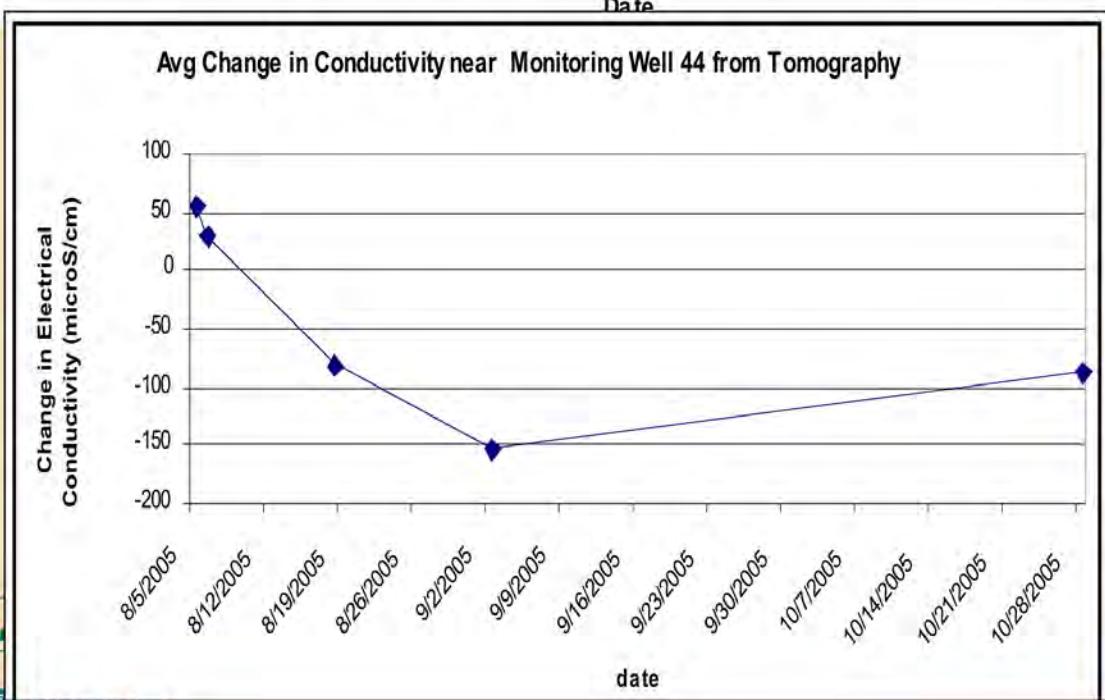
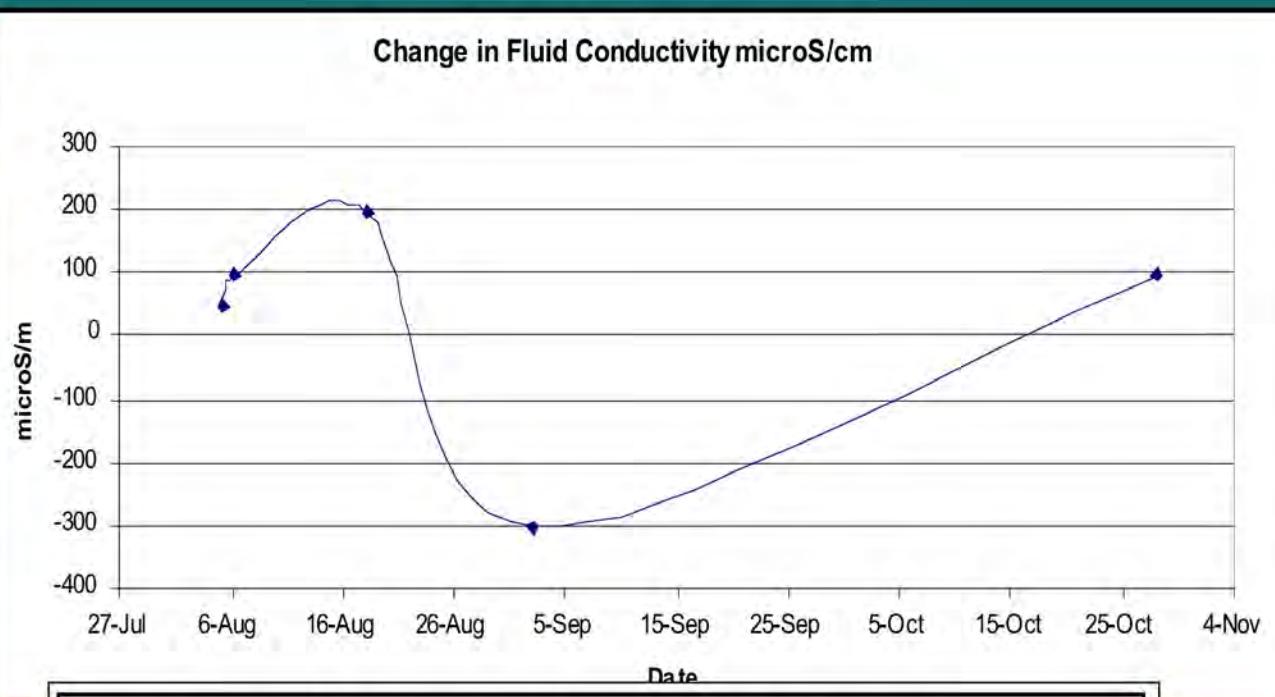




### 3. Interpretation of System Transformations

Comparison of tomo EC and metals at/near Wellbore 44 suggest that:

1. Metals decrease in concentration after injection;
2. Metal concentrations recover after pumping stops;
3. Electrical conductivity tomography values correlate with metals concentrations, even though expected quantity of precipitation is very



## Comparison of log and tomographic data:

*Change in tomography-estimated averaged EC near wellbore 44 generally agrees with fluid conductivity measured in wellbore 44*

## Summary: Geophysical Data at the 100 H Site

- ❖ Seismic, radar, and electrical lab and field signatures to HRC are in agreement;
- ❖ Sensitivity of seismic and radar attributes to HRC occur at different times;
- ❖ Small heterogeneity plays a role in HRC distribution;
- ❖ Averaged geophysical and geochemical signatures correlate and suggest that:
  - HRC initially injected at base of hole;
  - HRC quickly moves into higher K area;
  - In HRC Reaction front: No significant denitrification & Precipitates reduce electrical conductivity over time;
  - Conditions return to 'background' after pumping stops
- ❖ Questions/Problems
  - Vertical migration of lactate (along pvc?)
  - Mass of Fe and Cr ppt is very small – other ppt's?
  - What is going on in bottom of monitoring well?